Chapter 2
Physical Characteristics of the Illinois Coast

Introduction

The Illinois coast extends along 63 miles (101 km) of the southern-most reach of the western shore of Lake Michigan (Figure 2-1). The coast is the major physical feature of the greater Chicago metropolitan statistical area which in the 2000 census had a population of nearly 9.1 million people (U.S. Census Bureau 2003). This is the third largest metropolitan area in the nation and the most densely populated coastal area in the Great Lakes Region. No other coastal area in the Great Lakes has been urbanized and engineered to the degree that has occurred along the Illinois coast. In addition, the glacial processes that shaped all of the Great Lakes Region made the landscape of coastal Illinois particularly noteworthy. Near the western limits of Chicago is a unique and natural-occurring waterway passage between the Great Lakes and the Mississippi River system. Nowhere else on the North American continent does a comparable passage occur between these two continental-scale watersheds.

Political Geography

The Illinois coast lies between the coasts of Wisconsin to the north and Indiana to the south and east (Figure 2-1). The northern part of the Illinois coast is in Lake County; the southern part of the Illinois coast is in Cook County. Lake County, with a 2004 estimated population of 692,895, is one of the fastest growing counties in the state. Cook County, with a 2004 estimated population of 5,327,777, is the most populated county in the state. These two counties contain about 47 percent of the Illinois population (U.S. Census Bureau 2006).

Chicago is the largest municipality along the Illinois coast in both population and shoreline length. The 22 mile (35 km) Chicago shoreline comprises about 35 percent of the Illinois coast. North from Chicago is a series of nine lakeshore municipalities that are collectively referred to as the North Shore. These are affluent residential communities that began to grow in the mid to late 1800s as commuter rail provided access to and from Chicago (Ebner 1988).

The U.S. Navy's Naval Training Center Great Lakes separates the North Shore communities from an additional five municipalities along the state's Far-North Coast. These northern municipalities have a varied history including industry, manufacturing, and port activity. The Far-North Coast includes 9 miles (14.5 km) of state-owned shoreline along North Point Marina and Illinois Beach State Park. Despite the extent of state-owned shoreline, the municipal limits of Zion, Waukegan and North Chicago include some land area along the lakeshore. Of these five municipalities, Waukegan has the greatest extent of lakeshore.

Although the Chicago city limits extend to the Indiana state line and preclude lakeshore municipalities south of Chicago, navigable waterways provide a link to Lake Michigan for a series of South Suburban municipalities that border the far south limits of Chicago. These municipalities are Burnham, Calumet City, Dolton, Riverdale, Calumet Park, and Blue Island. Several of the municipalities include marinas and boat-launch facilities that service Lake Michigan recreational boating.

At and near the north limits of Chicago are two additional municipalities that border a waterway that provides a navigable link to Lake Michigan by way of the Chicago River system. These municipalities are Lincolnwood and Skokie.

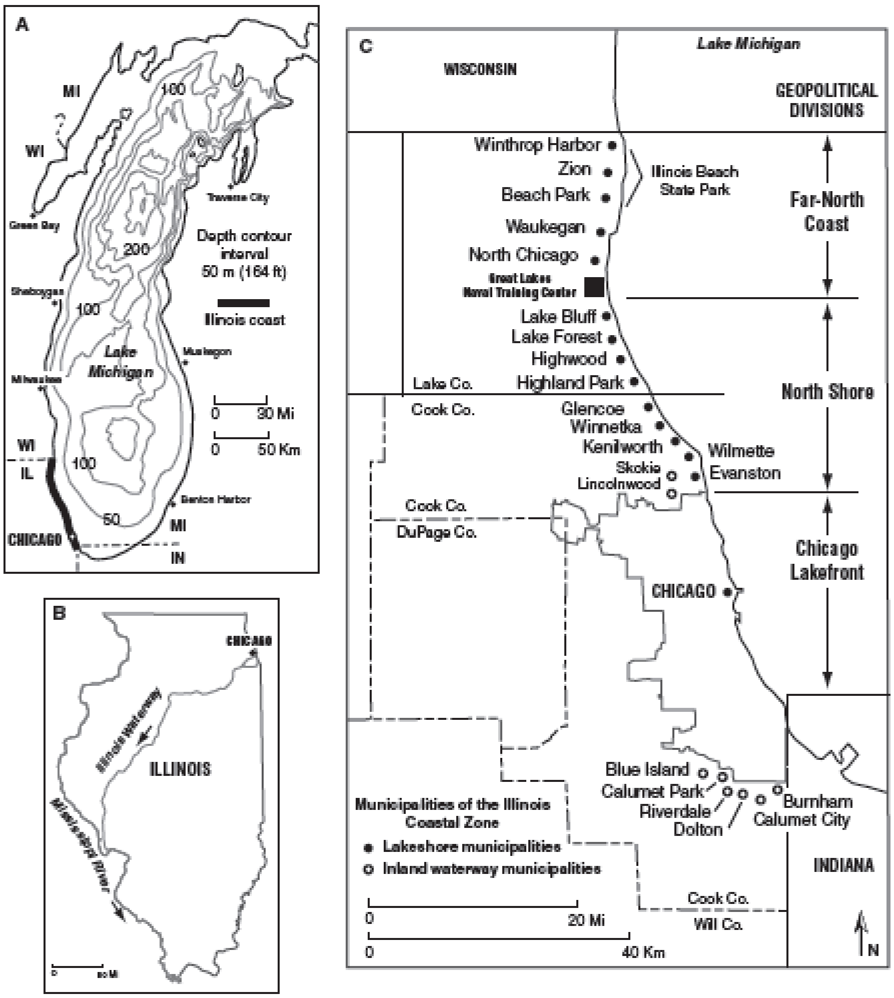


Figure 2-1. A) The Illinois coast is along the southern reach of the western shore of Lake Michigan. B) The Illinois waterway provides a navigable link between the Illinois coast and the Mississippi River. C) The fifteen municipalities that border the Illinois coast occur within three geopolitical divisions.

Coastal Geomorphology

The land bordering the Illinois coast has varied landscape characteristics that allow division into three geomorphic settings (Figure 2-2) (Chrzastowski 2005; Chrzastowski, Thompson and Trask 1994). These three settings have different coastal management challenges and opportunities.

Zion beach-ridge plain

From the Illinois-Wisconsin state line south to North Chicago, the land bordering the shore is a low-lying plain at most 10 to 15 feet (3 to 4.5 m) above mean lake level. Much of the southern plain in the vicinity of Waukegan Harbor has been altered for port and industrial land use. However, Illinois Beach State Park preserves the natural setting of undulating sand ridges and swales (Chrzastowski and Frankie 2000). The plain is up to one mile wide (1.6 km) at Zion.

Bluff coast

Along the coast between North Chicago and Winnetka, the lakeshore intercepts the Zion City and Highland Park Moraines (Figure 2-2). Long-term wave erosion along this morainal upland has resulted in bluffs that form the highest and steepest landscape along the Illinois coast. Maximum bluff heights of about 90 feet (27 m) occur along the southern Highland Park lakeshore.

The bluff slopes range from near vertical to about 45 degrees. Many segments of the bluff slope have been graded for erosion control. A discontinuous bluff face results from a series of steep-sided, V-shaped ravines that open to the lakeshore. These ravines originate as much as one mile inland from the shore and typically have intermittent streams that discharge to the lake.

Chicago lake plain

From Winnetka south to the Illinois-Indiana state line is an extensive plain that was totally or partially submerged in the recent geologic past. This submergence occurred during a series of phases of high water-level of ancestral Lake Michigan and its predecessor glacial Lake Chicago. The name "Chicago lake plain" refers to all of the land area that corresponds to the maximum extent of submergence when lake level was as much as 60 feet (18 m) higher than the historical mean (Willman 1971). Most of the City of Chicago occupies this plain. The plain continues into Indiana where it is known as the Calumet lake plain. The plain also has an outlying continuation across a narrow band of upland above the Zion beach-ridge plain.

Coastal Geology

Upland Sediments and Bedrock

The dominant material in the Illinois coastal zone is a compact, gray, silty and clayey till. The till may contain discontinuous layers of sand and gravelly sand. This till was deposited by glacial ice during the most recent (Wisconsin) glacial episode. The till is exposed along the coastal bluffs, as well as the material first encountered beneath most of the soils in the area. It also occurs beneath the beach and nearshore sand. The till has provided an exceptional foundation material along the coast for breakwaters and other shore structures.

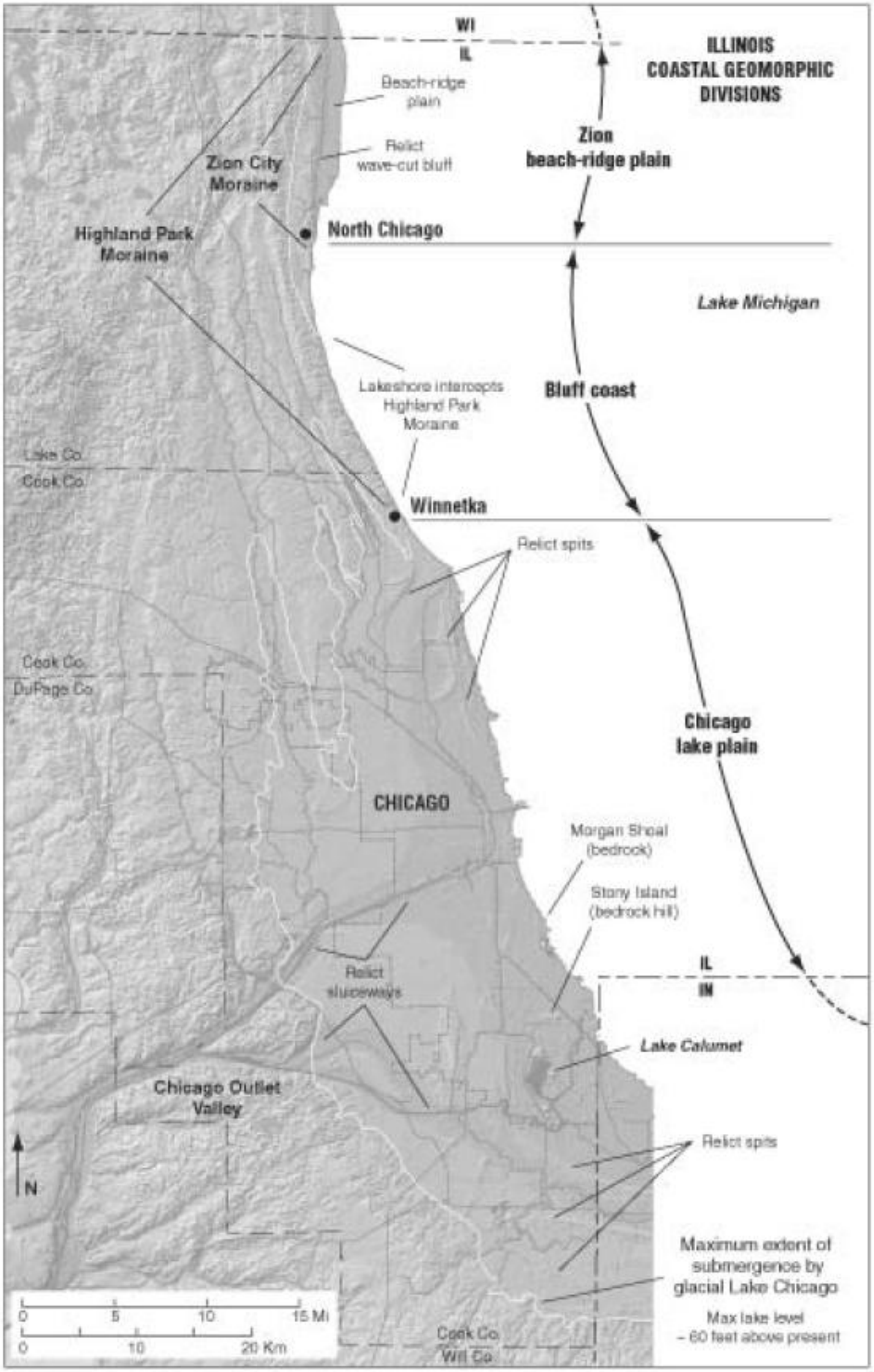


Figure 2-2. Glacial and coastal processes have resulted in three geomorphic divisions along the Illinois coast (modified from Chrzastowski 2005).

The till directly overlies the underlying regional bedrock which is Silurian-age dolomite (Willman 1971; Willman and Lineback 1970). The thickness of the till sequence above the bedrock is variable. In general, within the Illinois coastal area, the thickest till occurs in Lake County where thickness can be 300 to 400 feet (91 to 121 m). In Cook County, the thickness is generally no more than 100 feet (30 m) (Piskin and Bergstrom 1975).

Beach Sediments

Beach sediments along the Illinois coast consist of mixed sand and gravel. The primary source for the beach sediments was erosion of coastal bluffs. The low gradient of the two major rivers along the Illinois coast (Chicago and Calumet Rivers) prevented them from providing any significant sediment supply.

Many of the beaches along the Chicago lakeshore are constructed beaches built with placed sand originally mined from the lake bottom off the western Indiana coast (Chrzastowski 1991). Beach nourishment along erosion-prone beaches such as at Illinois Beach State Park has resulted in the import of sand from inland sand pits in western Lake County (Chrzastowski and Frankie 2000).

Coastal Processes

Wind and Waves

The orientation of the Illinois coast results in the influence by waves from either the northeast or southeast quadrants. The northeast quadrant has the greater fetch (*i.e.,* distance over water for wind to blow). Waves generated by winds from the northeast quadrant are the largest waves along the Illinois coast and have the net influence on coastal-sediment transport.

Offshore winds and calm-water conditions are common along the Illinois coast. When waves do occur they have an average wave height of 1.5 to 2 feet (.3 to .6 m) and an average maximum wave height of 8 feet (2.4 m). The largest waves along the shore rarely exceed 10 to 12 feet (3 to 3.6 m) (U.S. Army Corps of Engineers 1953). Large waves are most common in late fall, winter, and early spring.

Lake Level and Lake-Level Change

Lake Michigan has a mean water level of 578.9 feet (176.45 m) referenced to the International Great Lakes Datum (IGLD) of 1985. Because Lake Michigan is directly connected to Lake Huron and these two lakes share a common lake level, for hydrologic purposes this dual-lake system is commonly referred to as Lakes Michigan-Huron.

Lake Michigan water level is continually subject to change due to changes in the water budget. On an average annual basis, the Lake Michigan water level varies within a one-foot (0.3 m) range having high water in summer and low water in winter. This annual cycle is superimposed on lake-level changes occurring over multi-year and decadal time scales caused by weather and climate variations.

Through the historical record since 1919, the maximum range in mean monthly lake level in Lakes Michigan-Huron has been 6.3 feet (1.9 m). The low-water record occurred in March 1964; the high-water record occurred in October 1986 (U.S. Army Corps of Engineers 2006A).

Short-Term and Sudden Lake-Level Change

Prolonged northerly winds blowing along the axis of Lake Michigan have the potential of creating setup, which is a wind-generated rise in water level (U.S. Army Corps of Engineers 2006B). Along the southern

part of the Illinois coast the setup could reach a maximum of 1.7 feet (0.5 m). The potential setup decreases northward along the Illinois coast. Near Milwaukee, Wisconsin the maximum potential setup is 1.2 feet (0.3 m) (U.S. Army Corps of Engineers 1978).
A seiche is a sudden and potentially dangerous wave or series of waves. These are produced by sudden changes in air pressure and/or sudden downbursts of wind associated with fast moving storm fronts. Small seiches of one foot height or less are common along the Illinois coast (Illinois State Geological Survey 2005). These small seiches rarely cause problems. The highest recorded seiche along the Illinois coast reached 10 feet (3 m) and occurred on June 26, 1954 at Chicago's North Avenue Beach (Ewing, Press and Donn 1954). This seiche caused shore damage and the drowning of eight people.

Beach and Nearshore Ice

Conditions can be favorable for the development of ice along Illinois beaches and nearshore from December to March. Some years can have little or no ice. Other years can have multiple events of ice formation, breakup, and redevelopment. Wave action is the common factor causing ice break up rather than melting (Barnes and others 1994).

Littoral Transport

The dominant wave influence by northerly waves results in a net southward littoral transport along the Illinois coast. Waves from the southeast quadrant can influence a northward movement, but the stronger northerly waves counteract this influence and produce a net southerly transport.

Historically the Illinois coast has experienced considerable reduction in the volume of littoral sediment in transport. Coastal engineering along the Chicago lakeshore, particularly engineering in the vicinity of Chicago Harbor, has completely isolated the southern Chicago lakeshore from any littoral sediment supply from the north. Long-term reduction in the volume of littoral sediment transport has also occurred along the bluff coast as bluff erosion has been arrested and sediment supply to the littoral transport has been greatly reduced.

Geologic History of the Illinois Coast

Overview

The geologic framework for the Illinois coast began more than 460 million years ago as marine sediments were deposited that now comprise the regional bedrock of Silurian dolomite. Subsequent deposition of shales and sandstone provided the more easily erodible strata into which rivers could erode major drainage networks. The valleys associated with some of these ancient rivers guided the pathway for a series of continental ice sheets that advanced and withdrew over the past two million years. These multiple glacial episodes resulted in the erosion of the Lake Michigan basin as well as shaping and reshaping the bedrock surface.

The present landscape is the result of the most recent glacial event, the Wisconsin episode. Glacial ice was receding from the Illinois coastal area about 14,000 years B.P. (before present). After the ice withdrew there was wide fluctuation of water level in the Lake Michigan basin. At its extreme high, lake level was as much as 60 feet (18 m) higher than today, and at its extreme low lake level was as much as 262 feet (80 m) lower than today. Not until about 2,500 years B.P. did lake level begin to fluctuate within the seasonal and long-term range that has persisted through historical time (Figure 2-3).

The geologic history of the coastal area that we see today primarily relates to events of the past 15,000 years. This history can be divided into two components of glacial processes and coastal processes.

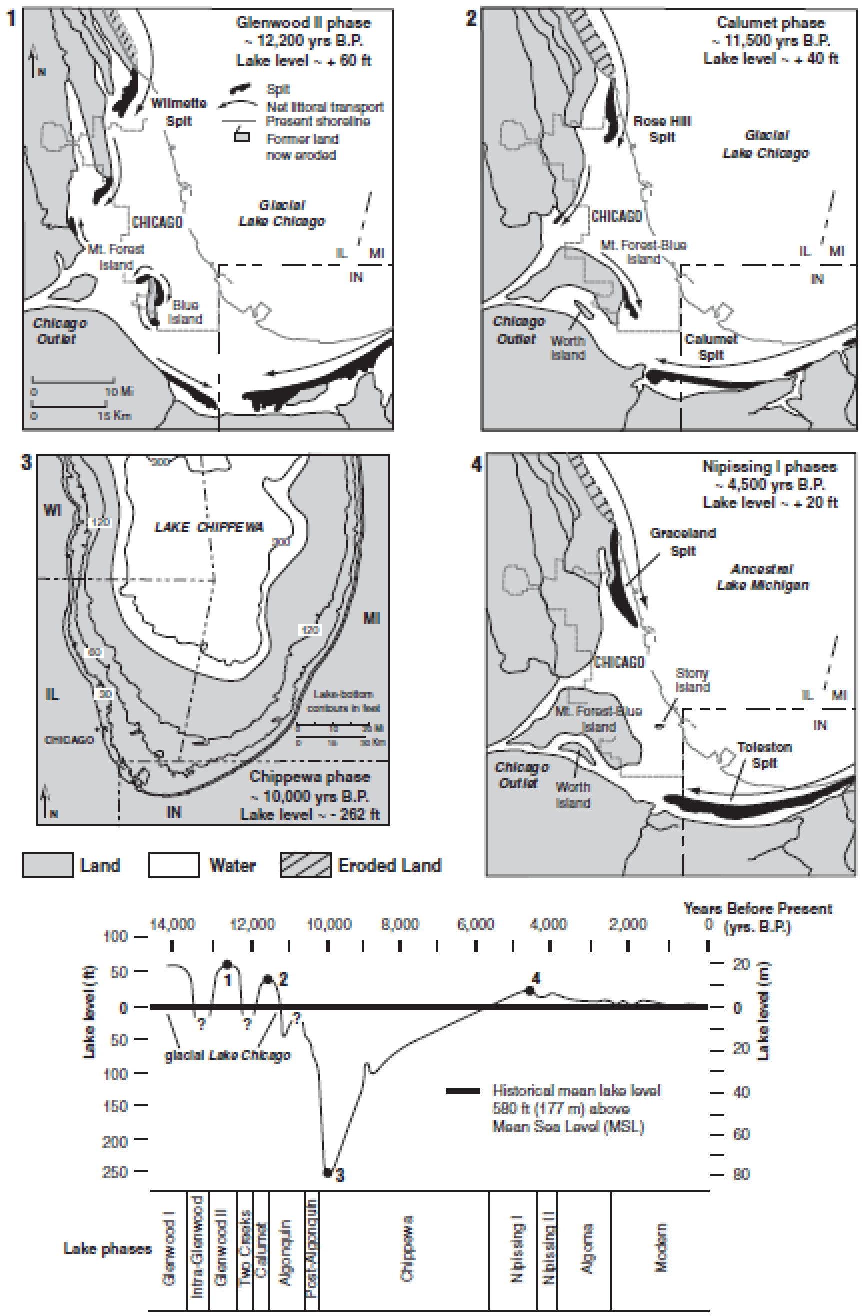


Figure 2-3. Lake-level curve for southern Lake Michigan for the past 14,000 years and paleogeography at four select lake-level elevations (modified from Chrzastowski and Thompson 1994; Colman et al. 1994).

Landscape Shaping by Glacial Processes

As glacial ice withdrew from northeastern Illinois, the resulting end moraines provided high ground that acted as a dam to retain a series of elevated water levels within the Lake Michigan basin. The name "Lake Chicago" refers to the lake that formed in the southern part of the Lake Michigan basin between the glacial ice and the end moraines. During these times, lake water drained westward through the Chicago Outlet Valley, which is the prominent Y-shaped erosional valley that cuts through the morainal uplands west of Chicago (Figure 2-2).

Landscape Reshaping by Coastal Processes

Over the past 5,000 years there were complex coastal changes as both wave-induced deposition and erosion shaped and reshaped the shore. All of the landscape of the Calumet area was shaped during this time as declining lake levels and sand deposition formed spits and beach ridges that formed high ground between the area's lakes and wetlands. North of Chicago, coastal erosion was dominant along the bluff coast. The historical position of the bluff coast is tens to hundreds of feet landward of where its position was several hundred to a thousand years ago.

Watersheds and Drainage

Watershed boundaries play a major role in how the Illinois coastal zone is defined for the ICMP. Thus the characteristics of the regional watersheds and surface drainage are important to define. The Illinois coastal area has surface drainage that is part of one of five watersheds (Figure 2-4):

- Lake Michigan watershed
- Des Plaines River watershed
- Chicago River watershed
- Little Calumet River watershed
- Calumet River watershed

The Calumet River watershed is technically part of the Lake Michigan watershed, but the Calumet River and its watershed have unique characteristics that warrant special division. The other three watersheds (Des Plaines River, Chicago River, and Little Calumet River) have drainage away from the lake. The northern Illinois coast is notable because this includes a broad area that has streams that drain to Lake Michigan (Figure 2-5).

The southern limit of ravines at Winnetka corresponds to the southern limit of streams entering the northern half of the Illinois coast. One additional stream south of Winnetka is Skokie Ditch which comes from several miles inland and reaches the lakeshore at Kenilworth. The Skokie Ditch is a relict of an early 20th century attempt at draining the Skokie Marsh which was an extensive wetland complex related to the Skokie River. Engineering between 1933 and 1942 to create the Skokie Lagoons rendered the Skokie Ditch a landscape relict (Hill 2000). Although the ditch may infrequently direct localized surface drainage to Lake Michigan, the coastal zone boundary ignores the inland watershed of the Skokie Ditch.

Other than the Skokie Ditch, from the southern limit of the ravines at Winnetka for about 27 miles (43 km) southward to the mouth of the Calumet River, there are no streams flowing to Lake Michigan. Other than a limited number of stormwater sewers, there is no appreciable upland drainage that reaches the lake. This results from the engineering of the Chicago River to reverse its flow direction as well as to the combined sewer system along this coastal reach that directs all sanitary and essentially all stormwater away from the lake.

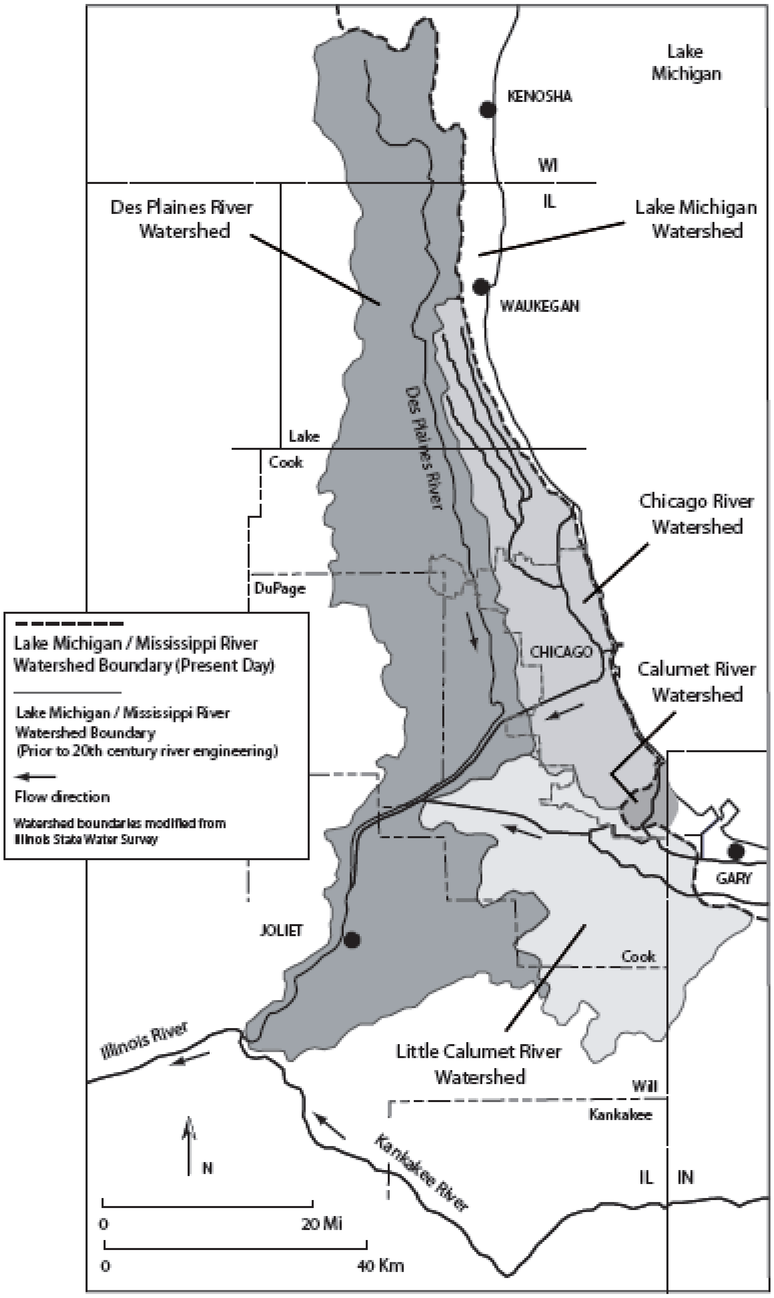


Figure 2-4. Five major watersheds are important to the historical and present-day surface drainage of the Chicago area. Prior to 20th century river engineering the Chicago River and Little Calumet River Watersheds discharged to Lake Michigan. Today they discharge to the Des Plaines River (modified from Chrzastowski 2005).

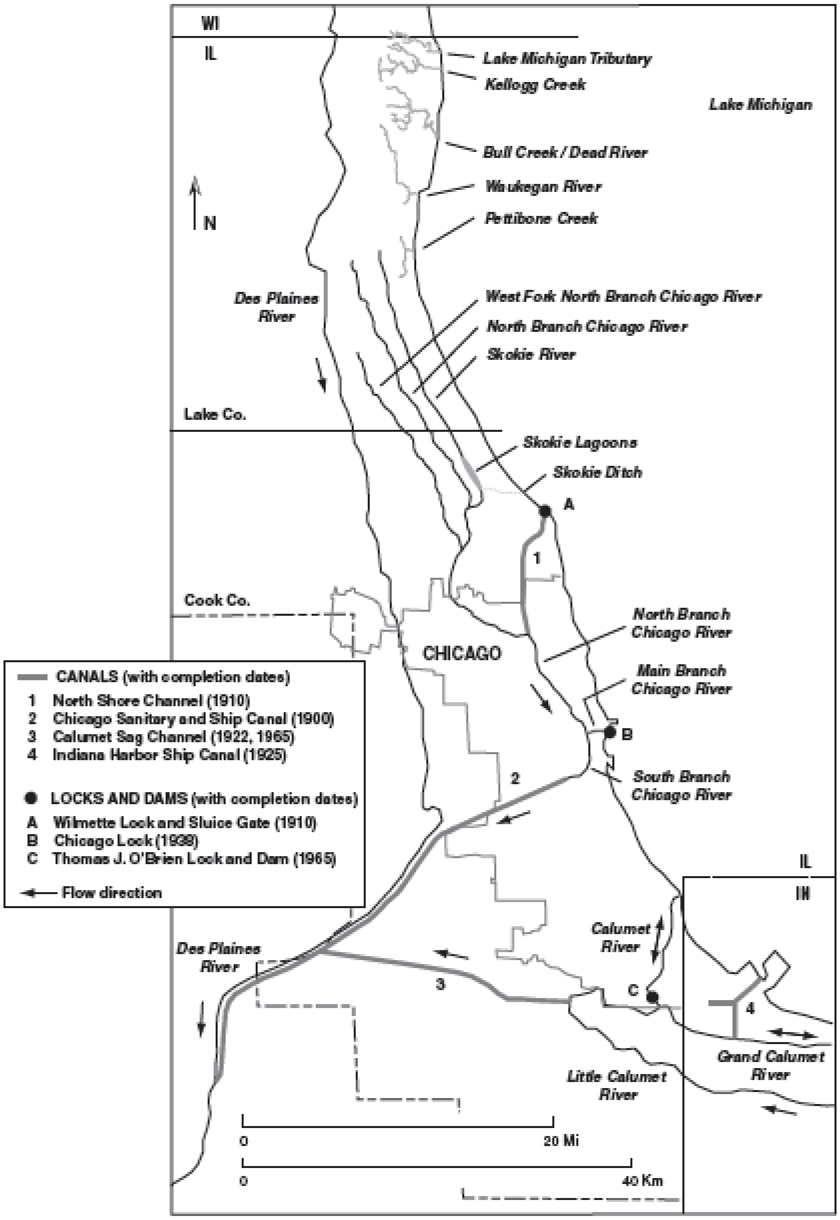


Figure 2-5. The rivers, streams, and waterways of the Chicago area and their flow directions result from a combination of glacial and coastal processes that shaped the landscape and 20th century river/canal engineering (modified from Chrzastowski 2005).

At the far southern end of the Illinois coast, the Calumet River provides drainage to Lake Michigan from Lake Calumet, Wolf Lake, and wetlands in the Lake Calumet/Wolf Lake area. The Calumet River primarily functions as a commercial waterway linking Lake Michigan with Lake Calumet and provides the navigation link between Lake Michigan and the Little Calumet River.

In its natural setting, there were two river systems (Chicago and Calumet Rivers) draining most of the Chicago lake plain to Lake Michigan (Figure 2-4). Today the Chicago and Little Calumet Rivers flow away from Lake Michigan. The history of this river engineering is briefly discussed in the following two sections.

History of Engineering the Chicago River

In the mid to late 1800s, the Chicago River served as the main sewer for the city. Although this contaminated water discharged to Lake Michigan, the lake was also the source of Chicago's potable water. The engineering solution to this water-quality issue was construction of the Chicago Sanitary and Ship Canal. Under the jurisdiction and management of the Sanitary District of Chicago (SDC), now known as the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), this project was completed in 1900. The 28 mile (45 km) canal links the South Branch Chicago River with the Des Plaines River. The canal provided for commercial river traffic as well as causing gravity-driven reversed flow direction in the South Branch Chicago River and the Main Branch so that river flow was away from Lake Michigan.

The 1900 river diversion had no influence on the dynamics of the North Branch Chicago River. Times of low flow on the North Branch limited the movement of sewage that the river received. In addition, there was a need to prevent lake discharge of sewage from lakeshore communities immediately north of Chicago. In 1910 the SDC completed the North Shore Channel. The channel intercepted combined sewer discharge from Evanston and Wilmette. A sluice gate separated lake and channel water while allowing lake water to be brought into the channel to increase the channel head and improve southward flow.

During times when river level was above lake level the flow direction along the Main Branch could revert to flowing toward the lake. This problem was addressed in the 1930s by building bulkheads and controlling works in the vicinity of the Chicago River mouth to form a physical barrier between the river and the lake. The Chicago Lock was completed in 1938 to provide navigation to either side of this physical divide. Originally built by the SDC, the Chicago Lock is now operated by the U.S. Army Corps of Engineers.

History of Engineering the Little Calumet River

In the early 1800s and the earliest settlement in the Lake Calumet vicinity, the Little Calumet River flowed into Illinois from Indiana for about nine miles beyond the state line to where it hooked back toward the east. This eastward flowing segment of the river was joined by water draining from Lake Calumet to form the Grand Calumet River which continued east and discharged to Lake Michigan in what is now Gary, Indiana (Chrzastowski and Thompson 1994; Schoon 2003).

Where the Little Calumet River made its turn from west to east was the remnants of the glacial sluiceway leading westward to the Chicago Outlet. This naturally occurring low area was used in construction of the Calumet Sag (or Cal-Sag) Channel. Built by the SDC and completed in 1922, this channel linked the Little Calumet River with the Chicago Sanitary and Ship Canal. Widening and other canal improvements occurred in 1965. This canal provides commercial navigation as well as diverting river flow of the Little Calumet River away from Lake Michigan. The physical barrier between Lake Michigan water and water of the Little Calumet River is the O'Brien Lock and Dam. The lock and dam, completed in 1965, is a facility of the U.S. Army Corps of Engineers.

Lake Michigan Flow Diversion

The 20th century construction of the Chicago Sanitary and Ship Canal and the Calumet Sag Channel provided the opportunity for Lake Michigan water to be diverted to the Mississippi River system by way of these engineered waterways. These two waterways could function as an outlet for Lake Michigan and, if unregulated, flow volume would only be limited by the cross-sectional dimensions along these waterways and flow management near the downstream end of the Chicago Sanitary and Ship Canal at Lockport.

The volume of Lake Michigan water that Illinois can divert through these waterways is limited by a decree of the U.S. Supreme Court (Wisconsin v. Illinois, 388 U.S. 426, 1967). Illinois is allowed to divert an average annual flow of 3200 cubic feet per second (cfs) which is 2.1 billion gallons per day. Illinois' diversion consists of three primary components: water supply, direct diversion and stormwater runoff.

Historical Shoreline Change

General

Coastal engineering has altered or influenced changes along nearly all of the 63 miles (101 km) of the Illinois coast. The only remaining shoreline segments that are free of any shore-protection structures are a three mile (5 km) reach in the South Unit of Illinois Beach State Park and adjoining shore to the south as well as a few isolated locations along the bluff coast.

The most extensive historical shoreline change along the Illinois coast has occurred along the Chicago shoreline. Other areas of major historical shoreline change along the Illinois coast are at the north and south ends of the Zion beach-ridge plain respectively near North Point Marina and Waukegan Harbor, and the area at and near Lake Calumet.

Chicago Lakeshore

Shoreline change along the Chicago lakeshore began in 1833 with the entrapment of littoral sand against the north jetty at the Chicago River mouth. By 1869, nearly 70 acres of sand accumulation had occurred north of the north jetty.

In the late 1800s, there was continued filling to make land in the vicinity of the Chicago River mouth primarily for rail and maritime commerce. There was also growing interest in making new land for lakeshore parks. Chicago has a unique history among coastal cities in the planning and execution of extensive projects to build new shore land and shape the urban shoreline for public use (Wille 1972).

The building of a park-dominated shoreline required constructing a new shoreline further in the lake, armoring this shoreline to prevent erosion, and building harbors and beaches at select locations. More than 5.5 square miles (14 km^2) of Chicago's lakefront land resulted from the late 19th and early 20th century lakeshore construction (Figure 2-6). Nearly all of the fill material was sand or clay either mined from the lake bottom or from dune deposits along the Indiana shore (Chrzastowski 1991). A second generation of lakeshore construction began in the 1990s. This was needed to replace the original generation of timber and stone shore protection with steel sheetpile and reinforced concrete.

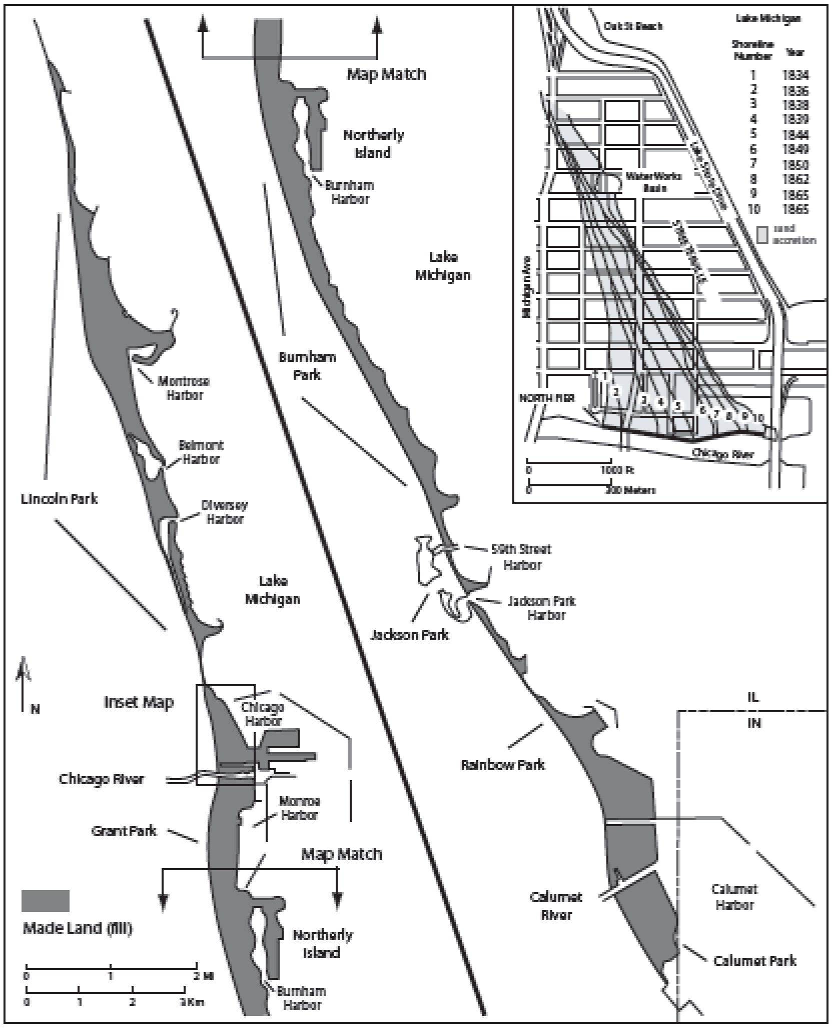


Figure 2-6. Historical shoreline change along the Chicago lakeshore has involved extensive lakefilling to make new land with a sculptured shoreline. The earliest historical shoreline change occurred in the vicinity of the Chicago River resulting from sand accretion against the historic North Pier jetty built between 1833 and 1844 (modified from Chrzastowski 1991).

North Point Marina Vicinity

North Point Marina is a state-owned and operated, 1500-slip marina on the Lake Michigan shore just south of the Illinois-Wisconsin state line. The marina was constructed between 1987-1989. It is built along a shoreline that has the most severe erosion recorded along the Illinois coast (Figure 2-7A). Shoreline recession has occurred at a long-term average rate of about 10 feet (3 m) per year (Chrzastowski and Frankie 2000). Prior to the State of Illinois acquiring this land in the 1970s, private residential property occupied the area (Bannon-Nilles 2003).

Waukegan Harbor Vicinity

Contrasting with the net erosion at the north end of the Zion beach-ridge plain near North Point Marina is the net accretion near the south end of the sand plain in the vicinity of Waukegan Harbor (Figure 2-7B). The USACE became involved in constructing a harbor at Waukegan in 1852 and completed a harbor project in the 1880s. The present harbor footprint results from expansion and reconstruction that occurred between 1902 and 1906 and additional improvements built between 1930 and 1932 (Bottin 1988). In 1984, the municipal Waukegan Marina was constructed on the south side of the original harbor complex.

Lake Calumet Vicinity

Lake Calumet and the surrounding Calumet area have had substantial shoreline, river line and wetland modification as the landscape of this area was shaped and reshaped for industry, commerce and port facilities (Schoon 2003). Filling on the perimeter of Lake Calumet has reduced the present (1997) lake area to about 52 percent of what existed in the late 1890s (Figure 2-8). Filling has occurred on the margins of Wolf Lake, and all of former nearby Hyde Lake has been filled. River engineering has straightened and repositioned segments of the Calumet River. Unlike much of the filling along the Chicago lakefront which used sand and clay, slag from steel mills was a major component in much of the filling in the Calumet area (Kay *et al.* 1997).

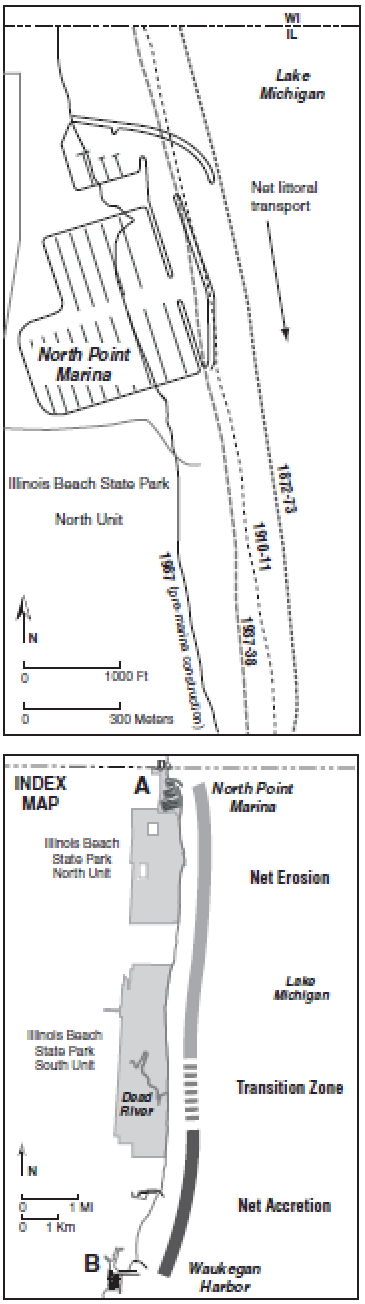
Other Notable Shoreline Modifications

The lakeshore municipalities north of Chicago each have municipal parks and beaches along the shore. Many also have waterworks facilities, several of which are adjacent to parkland. Limited usable land at the base of the bluffs resulted in lake filling for parks or public utilities. These are typically localized shoreline modifications that are no more than a few acres. The following describes the three largest lake fillings north of Chicago.

- *Evanston - Northwestern University:* Lakefilling for the construction of 73 acres of new land for the campus of Northwestern University occurred in the 1960s.

- *Wilmette – Gillson Park:* The 1907-1909 excavation of the North Shore Channel provided clay fill for construction of about 30 acres of land for Gillson Park.

- *Forest Park – Forest Park Beach*: This 22-acre park facility completed in 1987 includes a system of offshore breakwaters, beach cells, boat basin, parking and parkland.



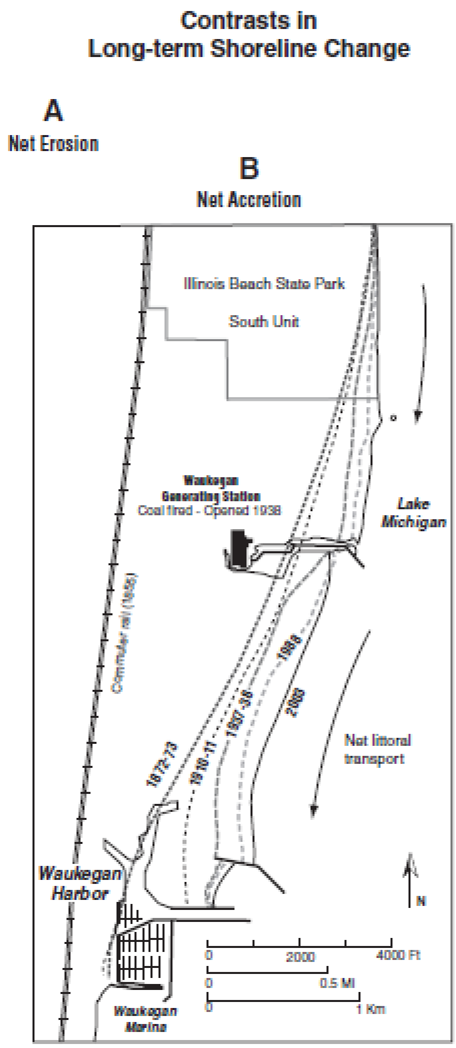


Figure 2-7. The Illinois shoreline between the Wisconsin state line and Waukegan Harbor has had a long-term history of net erosion in the north and net accretion in the south. The transition occurs along the shore in the South Unit of Illinois Beach State Park near the mouth of Dead River (modified from Chrzastowski and Frankie 2000).

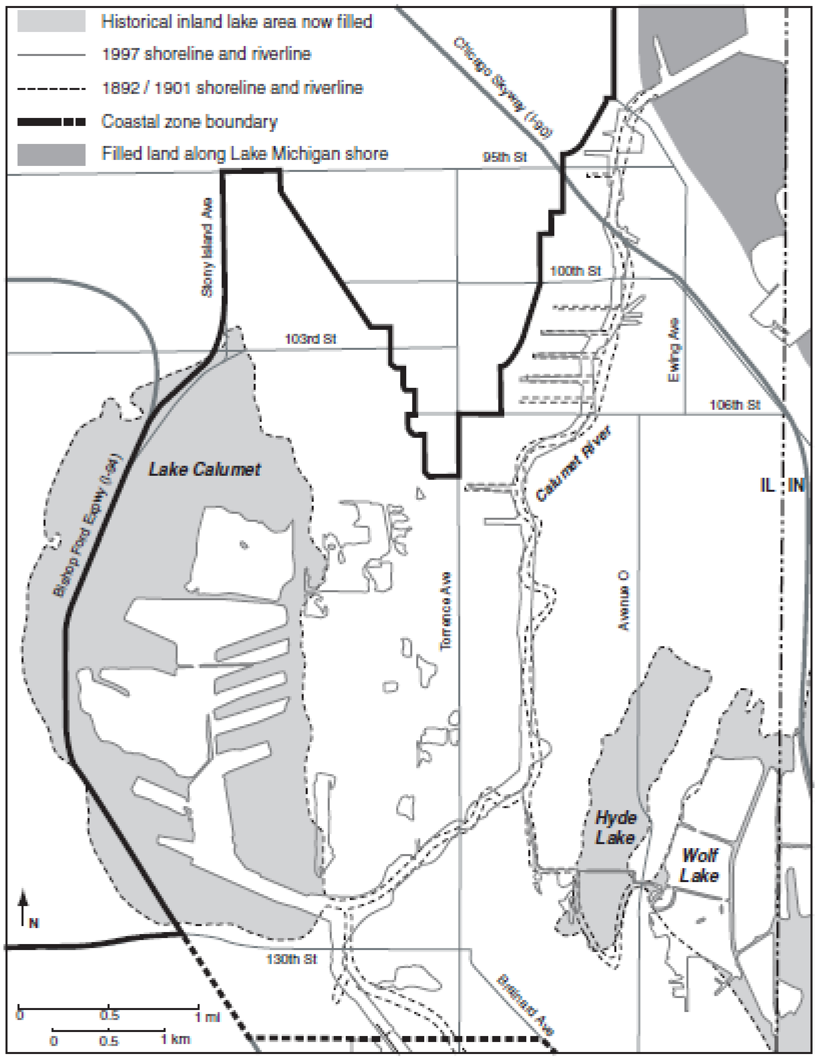


Figure 2-8. Comparison of present-day (1997) and historical shorelines, riverlines and lake area in the vicinity of Lake Calumet (map data from U.S. Geological Survey 1892; 1901; 1997).